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Effect of gout on 30-day survival in ICU patients: retrospective analysis of a large cohort of critically ill patients

Rouxin Li[1†], Yimei Ding[1†] and Luan Xue[1*]

Abstract

Background Gout is a chronic disease caused by the deposition of sodium urate crystals, which is prone to multiple comorbidities, especially cardiovascular and kidney diseases. Patients with gout have higher all-cause and cause-specific mortality. However, it is unclear whether gout affects survival in ICU patients.

Methods Data of the ICU patient cohort were obtained from the MIMIC IV database. The survival difference between the two groups was compared by Log-rank method. Cox regression was used to estimate the hazard ratio. Possible influencing factors were adjusted by matching. Quantitative variables were compared with Mann-Whitney/Wilcoxon test, and categorical variables were compared with Pearson's Chi-squared test.

Results The 30-day survival rate of gout patients in ICU was 87.13%, significantly higher than 84.88% in matched controls ($P=0.009$), with hazard ratio (HR) of 0.83 (95% CI: 0.73–0.96). HR was reduced to 0.74 (95% CI: 0.64–0.84) after adjusting Charlson comorbidity Index (CCI) and 0.72 (95% CI: 0.63–0.82) after adjusting sequential organ failure assessment (SOFA). HR rose to 0.86 (95% CI: 0.75–0.98) after matching the first diagnosis, but the difference was still statistically significant ($P=0.029$). After grouping matching for sepsis, HR decreased slightly, to 0.80.

Conclusion Gout showed a protective effect on 30-day survival in ICU patients, indicating that the understanding of gout deserves further exploration.

Keywords Gout, Hyperuricemia, Intensive care unit, MIMIC-IV, 30-day mortality

Introduction

Gout is a chronic disease caused by the deposition of sodium urate crystals in joint and non-joint structures. Increased serum uric acid (UA) concentration (hyperuricemia), a combination of increased production and reduced excretion, is a necessary causal factor in the development of gout. The pathological course of gout is generally thought to be hyperuricemia leading to the monosodium urate crystallisation, which then stimulate innate immune pathways and cause an acute inflammatory response [1].

The prevalence of gout among adults in the United States was approximately 5.1% [2]. According to the

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2021 Global Burden of Disease Study, it was estimated that about 55.8 million people worldwide have gout. The study did not directly attribute mortality to gout; however, it is known that untreated gout and elevated serum uric acid levels are risk factors for all-cause mortality. Individuals with heart disease who also have gout may have a higher risk of death compared to those with heart disease alone [3]. In fact, the harm of gout goes beyond the manifestation of the disease itself, and is reflected in the comorbidities. Renal impairment, hypertension, ischaemic heart disease, heart failure, diabetes and dyslipidaemia are all common comorbidities [4], which may result from a combination of pathological changes of gout and the patient's lifestyle.

Population-based epidemiological studies have identified gout as a clear risk factor for mortality. While previous studies have indicated the role of gout and hyperuricemia in infections and acute organ injuries, the outcomes of gout patients in ICU have yet to be fully explored [5, 6]. In this study, we explored whether patients with gout fared better in intensive care than patients without gout. The large database of more than 50,000 critically ill patients, MIMIC-IV (Multiparameter Critical Care Intelligent Monitoring), ensured an adequate sample size, while the sensitivity analyses for different indicators guaranteed the robustness of the study results. This study helps broaden the understanding of the impact of gout on life, which may be beneficial for better clinical decision-making.

Methods

Data

The data in this study were obtained from the MIMIC database through PhysioNet [7]. MIMIC-IV database is a publicly available, large, single-center critical care database. It includes health-related data for patients admitted to the intensive care units (ICUs) at Beth Israel Deaconess Medical Center (BIDMC) in Boston, Massachusetts, USA, between 2008 and 2019. The information available in the MIMIC-IV database includes patient measurements, orders, diagnoses, procedures, treatments, and de-identified free-text clinical notes [8]. The MIMIC-IV database is de-identified, and patient identifiers have been removed to ensure patient privacy. In addition, a Data Usage Agreement was obtained prior to data acquisition.

Patients

This cohort included records of first ICU admissions between 2008 and 2019 at BIDMC, except for individuals who were under 18 years of age or who were classified as needing enhanced protection. Patients were selected based on diagnostic codes, including ICD-9 and ICD-10 classifications. Patient screening was not limited to the first diagnostic position; thus, patients were included regardless of whether the disease was active. Specific diagnostic codes are provided in Additional file 1.

Adjustment and matching

Matching was employed to more accurately estimate the differences in survival rates between groups and the effects of various factors on these differences. This process was implemented through the R package "MatchIt", which provided methods including nearest neighbor matching, optimal pair matching, optimal full matching, generalized full matching, etc [9]. Nearest neighbor matching was selected as the main matching method in this study.

In the primary survival analysis, age and gender were used for matching, with a 1:1 ratio. In sensitivity analysis, different matching control groups were constructed according to different factors that needed to be adjusted. The matching factors of sequential organ failure assessment (SOFA) sensitivity analysis were age, gender and SOFA score. Adjustments for the Charlson Comorbidity Index (CCI) included not only age, gender, and overall scores but also the two sub-scores for renal disease and congestive heart failure, which differed significantly between patients with and without gout. Adjustments for sepsis were made by matching age, gender, and sepsis grouping.

Adjustments for the first diagnosis followed a two-step process. First, patients with the same first diagnosis were grouped into subgroups through precise matching. Patients who could not be matched with a control group for the first diagnosis were excluded at this stage. In the second step, patients were matched by age within each subgroup. Gender was not included as a matching factor due to the insufficient number of patients in most subgroups to support gender matching.

After matching, the effect was assessed using the *P*-value and standardized mean difference (SMD). A *P*-value > 0.05 meant that the matching result was good and there was no statistical difference between the groups. However, a *P*-value < 0.05 with an SMD < 0.2 was also accepted, because the effect difference was within an acceptable range [10].

Missing data

Missing values in this study were all below 5%, except for respiratory and liver scores in the SOFA. The original data were used for feature comparison between groups, and the interpolated data were used for Cox regression analysis and intermediate analysis. The missing data were Multivariate Imputation by Chained Equations (MICE) and realized by the R package "MICE" [11].

Variables

SOFA was used to assess the extent of multiple organ failure in patients [12]. In this study, SOFA scores at admission were analyzed as continuous variables rather than categorical variables. CCI was used to assess the number of patients with comorbidities [13], while systemic inflammatory response syndrome (SIRS) was used to assess the systemic inflammatory response of patients [14], both of which were treated as continuous variables. Nosocomial infection was defined as a positive culture result 48 h after admission, except for those with a positive culture result within 48 h [15]. The diagnosis of sepsis was based on Sepsis 3.0 [16]. Sepsis and nosocomial infection were both binary variables. The follow-up period was 30 days after hospital admission. In Additional file 3, matching models of SOFA, CCI and Sepsis in sensitivity analysis are provided respectively.

Statistical analysis

Given that most variables did not adhere to normality assumptions, the Mann-Whitney/Wilcoxon test was used to compare continuous variables, while Pearson's Chi-squared test and Fisher's Exact test were used to compare categorical data [17, 18]. These tests were implemented through the R package "tableone". The log-rank test was used to compare the difference of survival curves between the two groups, and Cox proportional risk regression model was constructed by the R package "survival" [19].

Results

Population

The study included a cohort of 50,920 patients from BIDMC, all of whom were admitted to the ICU for the first time. Patients in the cohort were separated based on whether they included a diagnosis of gout, of which 2,976 included. The results showed that the average age of gout patients was 72.84 years, and the proportion of male patients was 74.9%, both of which were much higher than those of patients without gout. In addition, the length of stay in the hospital and the length of stay in the ICU were longer in patients with gout. Table 1 presents basic information for patients with or without gout.

Survival analysis

The results from the unmatched patients showed no significant difference in survival between those with and without gout ($P = 0.999$). However, it was observed that the admission age in the gout group was significantly higher than that in the control group (Table 1), and the proportion of males was also significantly higher, which would affect the survival rate. Patients were therefore matched according to age and gender. After matching, the differences in age and gender between groups were not statistically significant. The 30-day survival rate was analyzed again, and the survival rate in the gout group was 87.13%, which was significantly higher than 84.88% in the control group ($P = 0.009$), while the HR was 0.83 (95% CI: 0.73–0.96). Figure 1 performs the Kaplan-Meier curves before and after matching.

Sensitivity analysis

In order to verify the stability of the results, several important scores that may affect the survival rate were analyzed and adjusted. Table 2 displays the CCI, SOFA and SIRS of patients after matching. Figure 2 illustrates the impact of adjustment of confounding factors on HR.

The average SOFA score in the gout group was 4.85, significantly higher than the 4.42 in the control group, indicating that gout patients exhibited more pronounced multiple organ failure. The difference mainly lay in renal score, which was 1.27 points in the gout group and 0.83 points in the control group, with $P < 0.001$ and SMD > 0.2. In addition, the gout group had a lower central nervous

Table 1 Patient characteristics

	Before Matched				After Matched			
	Without Gout (*n* = 47944)	With Gout (*n* = 2976)	*P*	SMD	Without Gout (*n* = 2976)	With Gout (*n* = 2976)	*P*	SMD
Age (Median(IQR))	66.16 (53.86, 77.81)	73.91 (65.05, 82.09)	< 0.001	0.558	74.59 (65.32, 82.78)	73.91 (65.05, 82.09)	0.224	0.002
Gender (Male%)	26,210 (54.7)	2230 (74.9)	< 0.001	0.434	2227 (74.8)	2230 (74.9)	0.952	0.002
Race (%)			< 0.001	0.157			0.001	0.120
Asian	1392 (2.9)	104 (3.5)			89 (3.0)	104 (3.5)		
Black	4323 (9.0)	317 (10.7)			233 (7.8)	317 (10.7)		
Hispanic OR Latino	1880 (3.9)	62 (2.1)			77 (2.6)	62 (2.1)		
Other	1881 (3.9)	81 (2.7)			104 (3.5)	81 (2.7)		
Unknown	6346 (13.2)	330 (11.1)			376 (12.6)	330 (11.1)		
White	32,122 (67.0)	2082 (70.0)			2097 (70.5)	2082 (70.0)		
Length of Stay In Hospital (Median(IQR))	6.43(3.79, 10.97)	7.13(4.41, 11.76)	< 0.001	0.034	6.76 (4.08, 11.22)	7.13 (4.41, 11.76)	0.001	0.019
Length of Stay In ICU (Median(IQR))	1.87(1.08, 3.51)	1.99(1.14, 3.64)	0.003	0.014	74.59 (65.32, 82.78)	73.91 (65.05, 82.09)	0.270	0.023

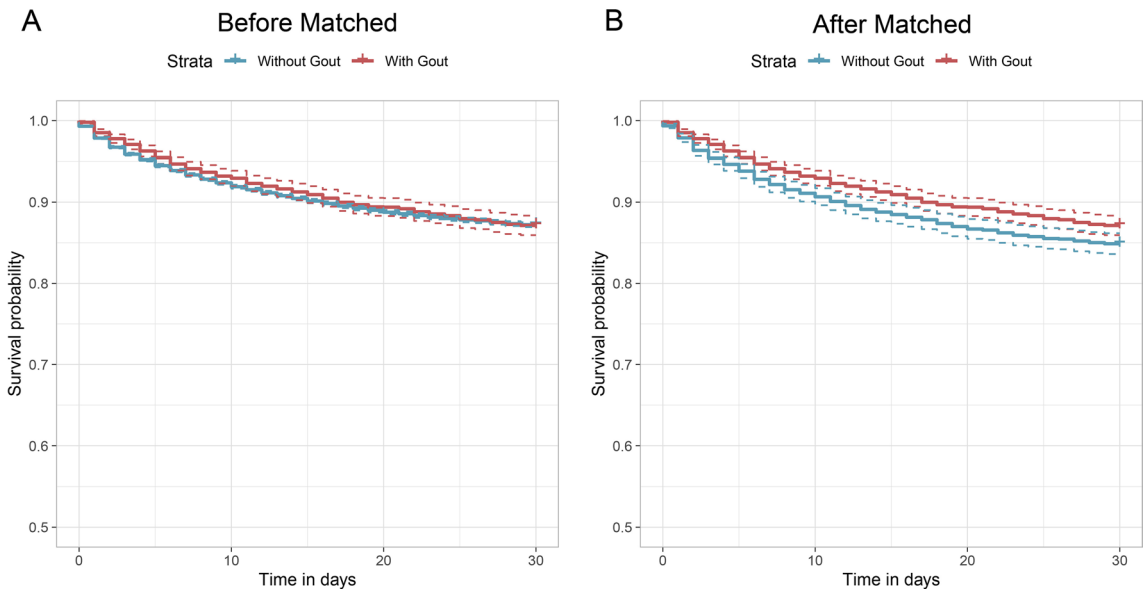

Fig. 1 The Kaplan-Meier curves before and after matching. (**A**) The Kaplan-Meier curve before matching. (**B**) The Kaplan-Meier curve after matching

system (CNS) score and a higher respiratory score than the control group. When SOFA scores were matched, the difference was more pronounced, with HR declining to 0.72 (95% CI: 0.63–0.82).

The CCI score also differed significantly, averaging 6.22 in the gout group compared to 5.51 in the control group. This suggested that gout patients generally had more comorbidities, notably congestive heart failure and renal disease, which differed significantly between groups ($P < 0.001$, SMD > 0.2). Interestingly, gout patients appeared to have lower cerebrovascular disease scores ($P < 0.001$, SMD = 0.108), suggesting that a smaller proportion of gout patients had cerebrovascular disease compared to the control group. Given the potential impact of comorbidities on survival, patients were matched according to the CCI. In particular, in addition to total scores, kidney disease and congestive heart failure scores were also matched because they varied widely between groups. After matching for CCI, the 30-day survival rate of the control group was 83.00%, still significantly lower than the 87.13% in the gout group, with an HR of 0.74 (95% CI: 0.64–0.84).

In addition to comorbidities, the main reason for the patient's admission was also an influential factor that could not be ignored. The first diagnosis of admission was observed to be statistically different between patients with or without gout ($P = 0.025$). Patients with gout were more likely to be admitted to hospital for kidney failure, but less likely to have intracerebral hemorrhage and acute respiratory failure. Additional file 2 presents the top ten first diagnoses in patients with or without gout. Matching the patient's first diagnosis was necessary to validate the robustness of the results. After matching the first diagnosis, the HR was 0.86 (95% CI: 0.75–0.98), and the difference was statistically significant ($P = 0.029$), but the gap was smaller than in previous analyses.

Sepsis was another factor considered, as the gout group had a higher rate of sepsis (48.7%) compared to the control group (45.8%). After matching sepsis, the HR decreased slightly to 0.80 (95% CI: 0.70–0.91), and the difference between the two groups was still significant ($P = 0.001$).

Systemic inflammatory response and nosocomial infection rates were also thought to be closely related to survival. However, no significant difference was found in either SIRS or nosocomial infection rates between the two groups after matching for age and gender, suggesting that the difference in 30-day survival between gout and non-gout patients was likely independent of these factors.

The results of sensitivity analysis showed the robustness of the main outcome, with HR decreasing after adjusting SOFA and sepsis and HR increasing after adjusting the first diagnosis.

Effect of glucocorticoid on 30d survival

Glucocorticoids are commonly used to manage acute gout attacks and are a key drug in the treatment of severely ill patients, likely impacting patient survival. The proportion of glucocorticoid use in non-gout patients was 18.74%, and slightly higher in gout patients (19.89%), but the difference was not statistically significant ($P = 0.119$). Among patients with gout, there was no statistical difference in 30-day survival between those who were treated with or without glucocorticoids while in hospital ($P = 0.270$).

Table 2 The CCI, SOFA, and SIRS scores after matching

	Without Gout (*n* = 47944)		**With Gout (*n* = 2976)**		***P***	**SMD**
	Mean(SD)	**Median(IQR)**	**Mean(SD)**	**Median(IQR)**		
CCI	5.51 (2.76)	5.00 (4.00, 7.00)	6.22 (2.86)	6.00 (4.00, 8.00)	< 0.001	0.252
Myocardial Infarct	0.19 (0.40)	0.00 (0.00, 0.00)	0.23 (0.42)	0.00 (0.00, 0.00)	< 0.001	0.097
Congestive Heart Failure	0.28 (0.45)	0.00 (0.00, 1.00)	0.42 (0.49)	0.00 (0.00, 1.00)	< 0.001	0.312
Peripheral Vascular Disease	0.13 (0.33)	0.00 (0.00, 0.00)	0.17 (0.37)	0.00 (0.00, 0.00)	< 0.001	0.107
Cerebrovascular Disease	0.19 (0.39)	0.00 (0.00, 0.00)	0.15 (0.36)	0.00 (0.00, 0.00)	< 0.001	0.108
Dementia	0.05 (0.22)	0.00 (0.00, 0.00)	0.04 (0.19)	0.00 (0.00, 0.00)	0.021	0.06
Chronic Pulmonary Disease	0.24 (0.43)	0.00 (0.00, 0.00)	0.26 (0.44)	0.00 (0.00, 1.00)	0.095	0.043
Rheumatic Disease	0.03 (0.17)	0.00 (0.00, 0.00)	0.04 (0.20)	0.00 (0.00, 0.00)	0.016	0.063
Peptic Ulcer Disease	0.03 (0.16)	0.00 (0.00, 0.00)	0.03 (0.17)	0.00 (0.00, 0.00)	0.578	0.014
Mild Liver Disease	0.09 (0.28)	0.00 (0.00, 0.00)	0.09 (0.29)	0.00 (0.00, 0.00)	0.649	0.012
Diabetes Without CC	0.23 (0.42)	0.00 (0.00, 0.00)	0.28 (0.45)	0.00 (0.00, 1.00)	< 0.001	0.097
Diabetes With CC	0.09 (0.28)	0.00 (0.00, 0.00)	0.15 (0.36)	0.00 (0.00, 0.00)	< 0.001	0.194
Paraplegia	0.06 (0.24)	0.00 (0.00, 0.00)	0.03 (0.18)	0.00 (0.00, 0.00)	< 0.001	0.123
Renal Disease	0.21 (0.41)	0.00 (0.00, 0.00)	0.45 (0.50)	0.00 (0.00, 1.00)	< 0.001	0.533
Malignant Cancer	0.13 (0.34)	0.00 (0.00, 0.00)	0.12 (0.33)	0.00 (0.00, 0.00)	0.241	0.03
Severe Liver Disease	0.04 (0.18)	0.00 (0.00, 0.00)	0.03 (0.17)	0.00 (0.00, 0.00)	0.14	0.038
Metastatic Solid Tumor	0.06 (0.23)	0.00 (0.00, 0.00)	0.05 (0.21)	0.00 (0.00, 0.00)	0.105	0.042
Aids	0.00 (0.05)	0.00 (0.00, 0.00)	0.00 (0.04)	0.00 (0.00, 0.00)	0.405	0.022
SOFA	4.42 (3.23)	4.00 (2.00, 6.00)	4.85 (3.25)	4.00 (2.00, 7.00)	< 0.001	0.132
Respiration	1.88 (1.44)	2.00 (0.00, 3.00)	2.03 (1.43)	2.00 (0.00, 3.00)	0.012	0.102
Coagulation	0.58 (0.84)	0.00 (0.00, 1.00)	0.60 (0.83)	0.00 (0.00, 1.00)	0.106	0.027
Liver	0.50 (0.91)	0.00 (0.00, 1.00)	0.50 (0.89)	0.00 (0.00, 1.00)	0.937	0.007
Cardiovascular	1.27 (1.15)	1.00 (1.00, 1.00)	1.32 (1.16)	1.00 (1.00, 1.00)	0.086	0.035
CNS	0.71 (1.06)	0.00 (0.00, 1.00)	0.62 (0.99)	0.00 (0.00, 1.00)	< 0.001	0.092
Renal	0.83 (1.15)	0.00 (0.00, 1.00)	1.27 (1.25)	1.00 (0.00, 2.00)	< 0.001	0.365
SIRS	2.46 (0.97)	3.00 (2.00, 3.00)	2.45 (0.95)	2.00 (2.00, 3.00)	0.358	0.017

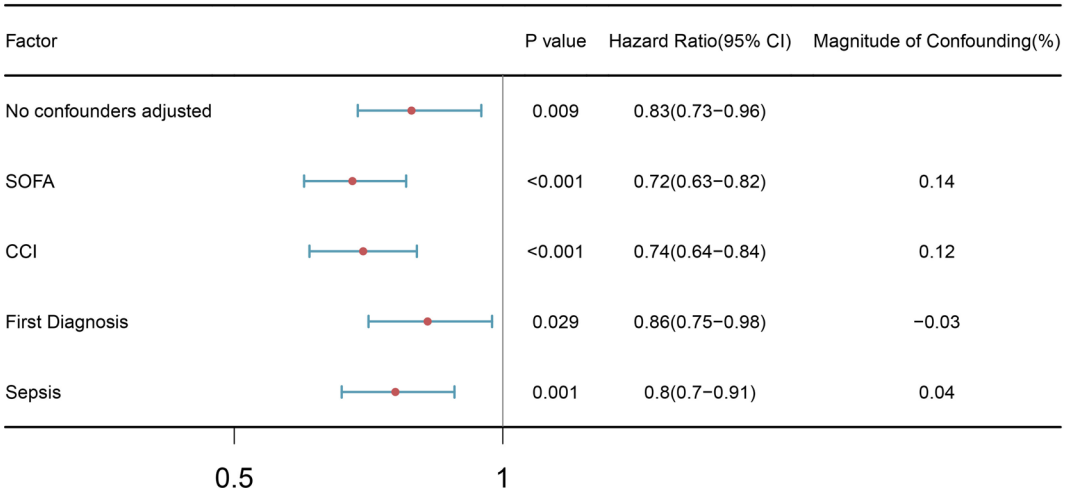

Fig. 2 The effect of adjustment for confounding factors

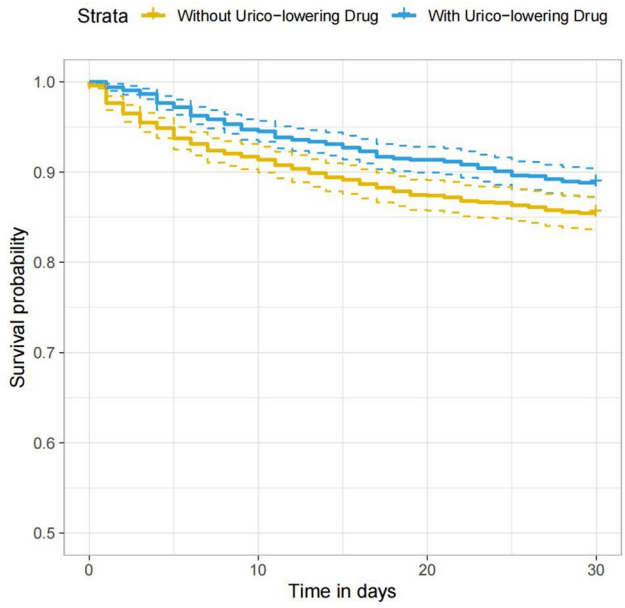

Fig. 3 The Kaplan-Meier curves of patients treated with or without urico-lowering drugs

There was a significant difference in the frequency of urico-lowering drug (Allopurinol, Febuxostat, Probenecid, Rasburicase, Penicillamine) use between gout and non-gout patients, with 50.17% of gout patients using urico-lowering drugs and only 2.46% of non-gout patients. Moreover, in patients with gout, the 30-day survival rate was significantly higher in those treated with urico-lowering drugs than in those without urico-lowering drugs (HR = 0.74 [95% CI: 0.61–0.91], $P = 0.004$), although CCI and SOFA scores were higher in those using urico-lowering drugs (Additional file 4). Figure 3 displays the Kaplan-Meier curves of patients treated with or without urico-lowering drugs.

Discussion

By analyzing a large cohort of critically ill patients from MIMIC-IV, we found that patients with gout had a higher 30-day survival rate after admission to the ICU than patients without gout, with approximately equal age and sex. Furthermore, since average SOFA and CCI scores and sepsis rates were higher in the gout group, the difference in survival between the two groups was even more significant after adjusting for these factors. In contrast, after adjusting for the first diagnosis at admission, although the survival rate of gout patients was still significantly higher than that of the control group, the gap narrowed. In addition, there was no significant difference in systemic inflammatory response and nosocomial infection rate between gout and non-gout patients.

The results of this study present an interesting paradox: despite having more comorbidities and higher levels of multiple organ failure upon ICU admission, gout patients demonstrated a higher 30-day survival rate.

The comorbidities of gout are worthy of attention, especially cardiometabolic-renal (CMR) conditions, represented by hypertension, myocardial infarction, hyperlipidaemia, type 2 diabetes mellitus and chronic kidney disease [20]. Although Mendelian randomization has not shown a broad causal relationship between serum uric acid and comorbidities [21], it is widely recognized that increasing prevalence and incidence of comorbidities are likely to contribute substantially to the rising burden of gout.

According to a meta-analysis, including 223,448 patients, gout was associated with an excess risk of CVD mortality and coronary heart disease mortality [22]. Imaging studies have shown that sodium urate crystal deposits in coronary artery plaques in gout patients have confirmed, and these crystals may play a role in the pathogenesis of inflammation that increases

cardiovascular risk in gout patients. Consistent with this, a higher rate of congestive heart failure was observed in gout patients compared to controls in this study.

Chronic kidney disease (CKD) is another important mortality associated comorbidity. The kidneys are the main excretion pathway of UA, and approximately 70% of uric acid is excreted through the kidneys [23]. UA reabsorption mediated by various molecules expressed in the proximal renal tubules is the key to the regulation of blood UA levels. These molecules include glucose transporter 9 (GLUT9) [24], urate transporter 1 (URAT1) [25], and human ATP-binding cassette, subfamily G, 2 (ABCG2) [26]. The hyperuricemia, except in the case of excessive uric acid synthesis, often indicates a decrease in the function of the kidney to excrete uric acid. UA crystals can cause tubule damage due to inflammation caused by physical mechanisms. Moreover, UA induces hypertension through its effects on endothelial function and impaired production of nitric oxide, which can also lead to chronic kidney damage [27]. Hyperuricemia also plays a pathogenic role in the development of CKD by inducing renal inflammation, endothelial dysfunction, and activation of the renin-angiotensin system [28]. The mechanisms of kidney injury caused by hyperuricemia are complex and varied, with only some aspects currently understood. However, the reduced survival expectancy associated with CKD has been observed in multiple studies.

A meta-analysis that included 15 unique cohorts of 99,205 individuals showed that the relative risk of CKD was 1.22 for every 1 mg/dL increase in serum uric acid levels [29]. Another meta-analysis involving 190,718 participants found a significant positive association between elevated serum UA levels and new CKD, and hyperuricemia was an independent predictor of the development of newly diagnosed CKD in non-CKD patients, with an OR of 2.35. Furthermore, a research showed that gout was associated with an excess risk of CVD mortality, with an unadjusted HR of 1.51 [22]. However, it is worth noting that there are also studies that suggest that the deterioration of kidney function in gout patients cannot be purely ascribable to gout but is related to aging, renal vascular disease, renal calculi with pyelonephritis or independently occurring nephropathy [30].

The above evidence is consistent with higher CCI and SOFA scores in the gout group, especially in cardiovascular and kidney disease. However, it is noteworthy that gout patients exhibited a higher 30-day survival rate than the control group, despite having more comorbidities and higher levels of multiple organ failure. Analysis of the first diagnosis showed that the main reasons for admission to the ICU were different in patients with and without gout. Gout patients were less likely to be admitted to the ICU for cerebral hemorrhage than the control group, and gout patients were also found to have lower cerebrovascular disease scores.

Uric acid can also perform beneficial functions that are beneficial for certain neurodegenerative diseases due to its antioxidant properties. A meta-analysis reported that gout was associated with reduced mortality from dementia with HR of 0.83 [31]. Additionally, studies found that higher serum uric acid levels were significantly positively associated with improved cognitive function. Higher serum uric acid was defined as the highest quartile (Q4), with concentrations ranging from 392.6 to 701.9 μmol/L [32]. A population based retrospective study, including 28,769 gout patients and 114,742 control patients, showed that gout patients had a lower risk of both non-vascular dementia (HR: 0.77) and vascular dementia (HR: 0.76) [33]. The neuroprotective effects of uric acid may partly explain the higher 30-day survival rate observed in gout patients.

However, after adjusting for the first diagnosis, there was still a statistical difference in 30-day survival between the gout and non-gout groups. This indicated that differences in major diagnoses between the two groups could not fully account for the survival discrepancy, warranting further investigation into the underlying causes. On the one hand, uric acid might have been beneficial for patients in terms of oxidative stress. On the other hand, recurrent inflammatory responses to uric acid crystals in patients with gout might have altered the patient's immune environment. Although the cause is still unclear, these results suggest that our understanding of gout as a disease needs to be expanded.

This study has some unavoidable limitations that should be noted. First, this is a retrospective analysis of data extracted from a database, and although the sample size is substantial, the risk of selection bias cannot be ignored. Although this study attempts to reduce the bias caused by the differences between the groups through matching, some potential imbalances that have not been considered still need to be vigilant. In addition, some immunological indicators are not routinely tested in an ICU setting, meaning that some underlying causes may not be analyzed. Furthermore, sociodemographic and economic variables are not included in the analysis, which may have limited the generalizability of the findings.

Conclusion

By analyzing a large cohort of critically ill patients from MIMIC-IV database, the study showed that patients with gout performed better 30-day survival after admission to the ICU than patients without gout when matched for age and gender. The result remained robust after adjustments for SOFA, CCI, and first diagnosis. This suggests

that the effects of gout on the internal environment are complex and diverse and deserve further exploration.

Abbreviations

UA	Uric acid
CVD	Cardiovascular disease
BIDMC	Beth Israel Deaconess Medical Center
SOFA	Sequential Organ Failure Assessment
CCI	Charlson comorbidity Index
MICE	Multivariate Imputation by Chained Equations
SIRS	Systemic inflammatory response syndrome
CMR	Cardiometabolic-renal
CNS	Central nervous system
CKD	Chronic kidney diseases
GLUT9	Glucose transporter 9
URAT1	Urate transporter 1
ABCG2	ATP-binding cassette, subfamily G, 2
OR	Odds ratio
HR	Hazard ratio
CI	Confidence interval
SMD	Standard Mean Difference

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41927-025-00469-z .

Supplementary Material 1: Additional File 1: Diagnostic code

Supplementary Material 2: Additional File 2: The first diagnosis of patients with and without gout

Supplementary Material 3: Additional File 3: Matching models of SOFA, CCI and Sepsis in sensitivity analysis

Supplementary Material 4: Additional File 4: Comparison of clinical characteristics and survival outcomes between Gout patients treated with and without urate-lowering drugs

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Author contributions
RL and YD were responsible for the study design, data acquisition, and initial analysis. LX contributed to the statistical analysis and interpretation of the data. RL, YD, and LX collectively drafted the manuscript, and all authors reviewed and approved the final version for submission.

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Data availability
The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request. The MIMIC IV database is publicly accessible and can be obtained through PhysioNet with proper approval.

Declarations

Ethics approval and consent to participate
The Institutional Review Boards of the Massachusetts Institute of Technology and Beth Israel Deaconess Medical Center approved the establishment of this public database. As this study was an analysis of MIMIC-IV database, the need for ethical approval and informed consent has been waived.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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